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General Employee Radiological Training Refresher 47968

1.1 splash



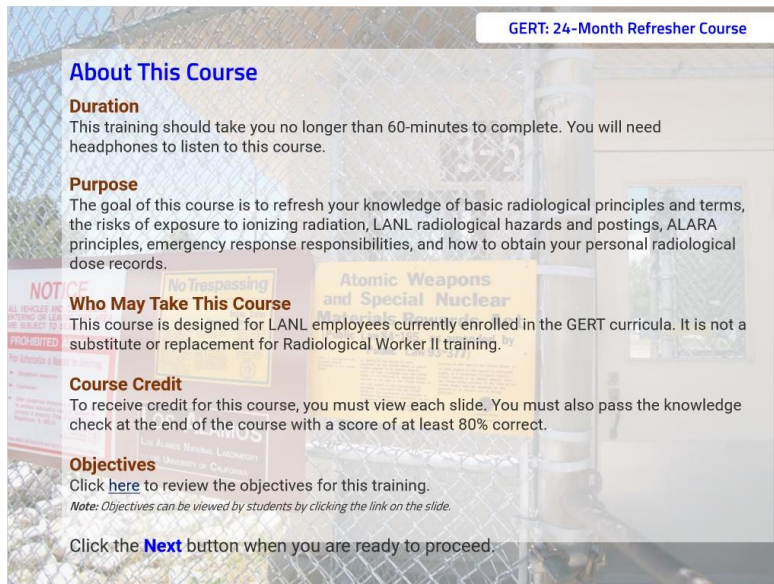
Notes:

1.2 Introduction



Notes:

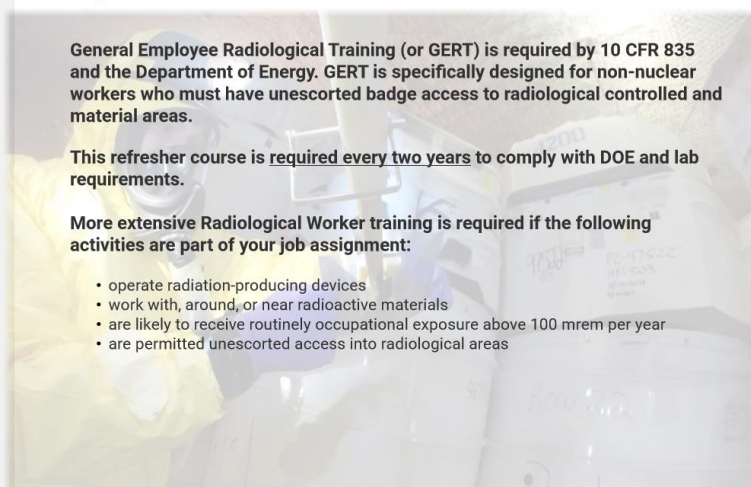
1.3 Course Intro



Narration: Welcome to the General Employee Radiological Training or GERT

course. This training is designed to refresh knowledge of basic radiological principles and terms, the risks from exposure to ionizing radiation, LANL's radiological hazards and postings, ALARA methods, your responsibilities during emergencies, and how to obtain your personal radiological dose records.

1.41 Rationale



GERT: 24-Month Refresher Course

Why Must I Take This Course?

General Employee Radiological Training (or GERT) is required by 10 CFR 835 and the Department of Energy. GERT is specifically designed for non-nuclear workers who must have unescorted badge access to radiological controlled and material areas.

This refresher course is required every two years to comply with DOE and lab requirements.

More extensive Radiological Worker training is required if the following activities are part of your job assignment:

- operate radiation-producing devices
- work with, around, or near radioactive materials
- are likely to receive routinely occupational exposure above 100 mrem per year
- are permitted unescorted access into radiological areas

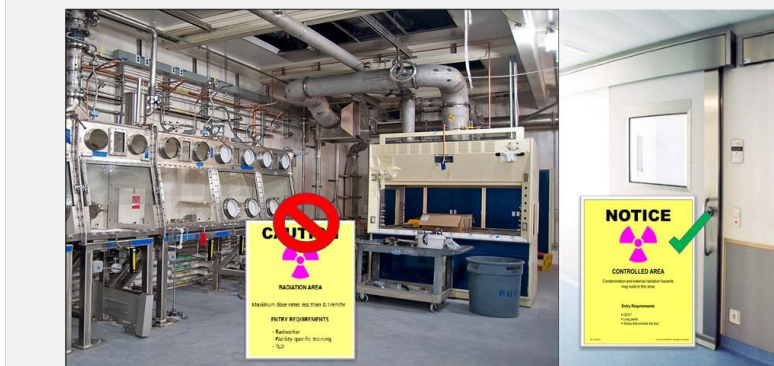
1.4 Access Qualification

Access Qualification

This training (GERT) **only** qualifies for unescorted access to:

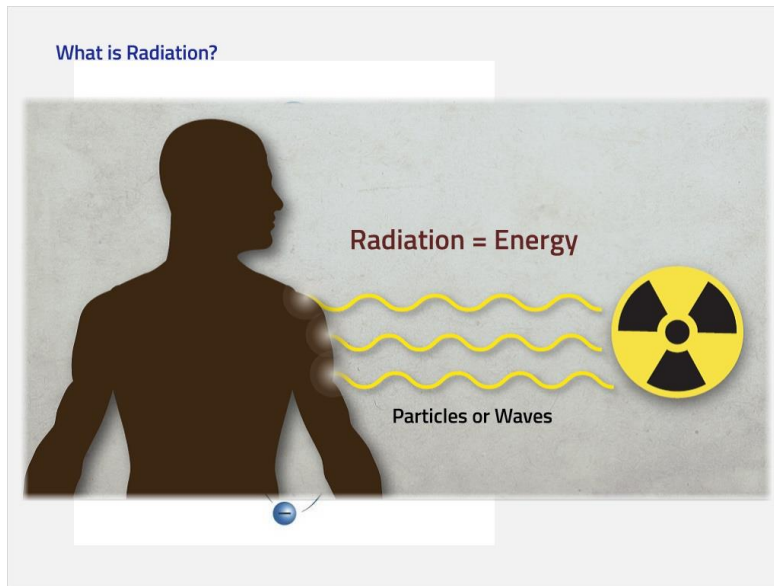
- Controlled Areas
- Radiological Material Areas

Completion of GERT does **NOT** allow access to enter radiological controlled areas without a dosimeter, handle radiological materials, enter areas posted as radiation, high radiation, contamination, or airborne radioactivity areas.



Narration: When you complete GERT, you will be qualified to access controlled areas at LANL without an escort and have the general radiological knowledge common to all DOE sites. However, completion of GERT does not allow you to enter radiological controlled areas without a dosimeter, handle radiological materials, enter areas posted as radiation, high radiation, contamination, or airborne radioactivity areas.

1.5 What is Radiation



Narration: Radiation is energy in the form of particles or waves. The fundamental unit of matter is the atom. Each atom is made up of three components that determine the atom's physical and chemical properties. Located in the nucleus, protons are positively charged particles that determine the element type. Neutrons are also found in the nucleus and have no charge but are needed for stability. Finally, electrons orbit the atom and have a negative charge.

1.6 Stable and Unstable atoms

Stable and Unstable Atoms

Atoms may be referred to as stable or unstable.

- Stable atoms do not contain excess energy.
- Unstable atoms contain excess energy.

STABLE	STABLE	UNSTABLE
Hydrogen	Deuterium	Tritium
1 proton 1 electron 0 neutrons	1 proton 1 electron 1 neutron	1 proton 1 electron 2 neutrons

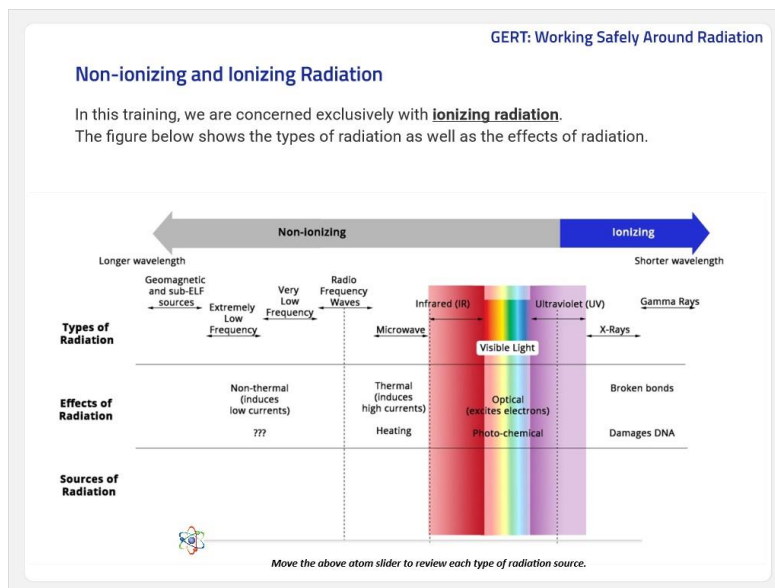
When energy is released during radioactive decay, it is known as ionizing radiation. Ionizing radiation is energy in the form of particles or waves that can penetrate matter.

Narration: What's the difference between stable and unstable atoms?

Atoms may be referred to as stable or unstable (that is radioactive) atoms. Stable atoms do not contain excess energy. Unstable atom contains excess energy. This is caused by an imbalance of the ratio of protons and neutrons in the atom's nucleus. These atoms release their energy in process known as radioactive decay.

When energy is released during radioactive decay that can remove an electron from an atom it is known as ionizing radiation. Once again, ionizing radiation is energy in the form of particles or waves that can penetrate matter.

1.7 Ionizing and Nonionizing Radiation



Narration:

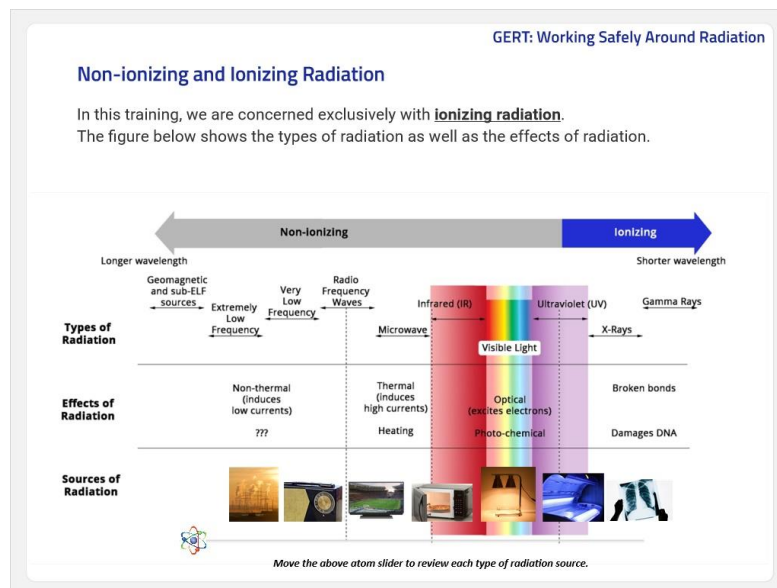
Radioactivity is the physical property, or capability of certain atoms to emit radiation as they decay or disintegrate. These radioactive atoms can be either be naturally occurring or man-made.

Radiation that does not contain enough energy to strip electrons from atoms is known as nonionizing radiation.

Conversely, when radiation contains enough energy to strip electrons from atoms it is known as ionizing radiation.

Move the slider to view examples of non-ionizing and ionizing radiation types.

Start (Slide Layer)



power_line (Slide Layer)

GERT: Working Safely Around Radiation

Nearly all high-voltage power transmission lines emit extremely low frequency (ELF) radiation. This low-frequency, non-ionizing radiation rarely emits sufficient radiation to affect us. However, these power lines do carry extremely high-voltage electricity, which is far more dangerous. The risk of radiation dose exposure and the risk of electrocution decreases as one moves farther away from these utility lines. *(This is non-ionizing radiation)*

The diagram illustrates the electromagnetic spectrum, categorized into non-ionizing and ionizing radiation. The non-ionizing region, highlighted with a blue circle, includes geomagnetic and sub-ELF sources, extremely low frequency, very low frequency, and radio frequency waves. The ionizing region includes ultraviolet, light, and X-rays. A slider at the bottom allows reviewing each type of radiation source.

Longer wavelength

Geomagnetic and sub-ELF sources

Extremely Low Frequency

Very Low Frequency

Radio Frequency Waves

Types of Radiation

Effects of Radiation

Sources of Radiation

Move the above atom slider to review each type of radiation source.

AM_radio (Slide Layer)

GERT: Working Safely Around Radiation

While long-term exposure from working nearby AM radio broadcasting towers has been shown to have potential health effects and cause some types of cancer, using an AM radio is not a significant source of radiation. *(This is non-ionizing radiation)*

The diagram illustrates the electromagnetic spectrum, categorized into non-ionizing and ionizing radiation. The non-ionizing region, highlighted with a blue circle, includes geomagnetic and sub-ELF sources, extremely low frequency, very low frequency, and radio frequency waves. The ionizing region includes ultraviolet, light, and X-rays. A slider at the bottom allows reviewing each type of radiation source.

Longer wavelength

Geomagnetic and sub-ELF sources

Extremely Low Frequency

Very Low Frequency

Radio Frequency Waves

Types of Radiation

Effects of Radiation

Sources of Radiation

Move the above atom slider to review each type of radiation source.

FM_radio (Slide Layer)

GERT: Working Safely Around Radiation

Both radio and television stations broadcast signals using electromagnetic waves, but the strength of the signal is linked to the power of the individual station. The radiation dose exposure for a given station is impacted by the antenna used, the power that the antenna receives, as well as the height of the antenna and the distance that a person is from that antenna. As with AM radios, there is minimal risk of exposure to radiation by listening to FM radio and watching television. *(This is non-ionizing radiation)*

Longer wavelength
Geomagnetic and sub-ELF sources
Extremely Low Frequency
Very Low Frequency
Radio Frequency Waves
Shorter wavelength

Non-ionizing
Ionizing

Sources of Radiation

Move the above atom slider to review each type of radiation source.

uwave (Slide Layer)

GERT: Working Safely Around Radiation

Microwave ovens are commonly used by consumers across the world as cooking aids. But microwaves themselves, as with other types of non-ionizing radiation, do not have enough energy to knock electrons out of atoms. A Federal standard (21 CFR 1030.10) limits the amount of microwaves that can leak from a microwave oven over its usable lifetime to 5 mW of radiation per square centimeter at approximately 2 inches from the oven surface. This limit is far below the level known to cause harm to people. *(This is non-ionizing radiation)*

Longer wavelength
Geomagnetic and sub-ELF sources
Extremely Low Frequency
Very Low Frequency
Radio Frequency Waves
Shorter wavelength

Non-ionizing
Ionizing

Types of Radiation

Effects of Radiation

Sources of Radiation

Gamma Rays
Broken bonds
Damages DNA

Move the above atom slider to review each type of radiation source.

heat_lamp (Slide Layer)

GERT: Working Safely Around Radiation

Radiation from most heat lamps falls within the visible spectrum, between IR and UV wavelengths. In most circumstances, visible light is not hazardous, and measurement of continuous visible light emissions is usually not necessary. Prolonged skin and eye exposure are the most common problems associated with heat lamps, so wearing goggles with IR-absorbing glass is recommended if someone will have long-term exposure to IR radiation. *(This is non-ionizing radiation)*

Longer wavelength → Non-ionizing → Ionizing → Shorter wavelength

Types of Radiation: Infrared (IR), Visible Light, Ultraviolet (UV), X-Rays, Gamma Rays

Effects of Radiation: Prolonged skin and eye exposure are the most common problems associated with heat lamps, so wearing goggles with IR-absorbing glass is recommended if someone will have long-term exposure to IR radiation.

Sources of Radiation: Heat lamp, Car window, Laser pointer, DNA

Move the above atom slider to review each type of radiation source.

tanning (Slide Layer)

GERT: Working Safely Around Radiation

Sunlamps and tanning beds promise users a bronzed body, but UV radiation from these devices poses serious health risks—including various types of cancers. There are two types of UV rays: UV-A (which penetrate to deep layers of the skin) and UV-B (which only penetrate the top layers of skin). Both types of rays cause skin damage and can lead to skin cancers. Whether one is exposed to direct sunlight or manufactured light in a tanning bed, skin and eye damage can easily occur. *(This is ionizing radiation)*

Longer wavelength → Non-ionizing → Ionizing → Shorter wavelength

Types of Radiation: Infrared (IR), Visible Light, Ultraviolet (UV), X-Rays, Gamma Rays

Effects of Radiation: Prolonged skin and eye exposure are the most common problems associated with heat lamps, so wearing goggles with IR-absorbing glass is recommended if someone will have long-term exposure to IR radiation.

Sources of Radiation: Tanning bed, Sun, Laser pointer, DNA

Move the above atom slider to review each type of radiation source.

medical (Slide Layer)

GERT: Working Safely Around Radiation

Radiation we get from x-rays (including dental), CT scans, and nuclear imaging is ionizing radiation. While ionizing radiation can impact our cells, routine exposure through medical imaging is fairly low: according to some research, the amount of radiation from a chest x-ray is about the same as 10 days of natural background radiation that we are all receive during our normal daily activities. So the benefits of medical imaging and x-rays far outweigh any radiation-associated cancer and cellular-level risks. *(This is ionizing radiation)*

Nuclear Medicine

Longer wavelength → Shorter wavelength

Types of Radiation: Microwave, Infrared, Visible light, Violet (UV), X-Rays, Gamma Rays

Effects of Radiation: Thermal induces (in currents) heating

Sources of Radiation: (Images of various radiation sources)

Move the above atom slider to review each type of radiation source.

1.8 radioactive contamination

Radioactive Contamination

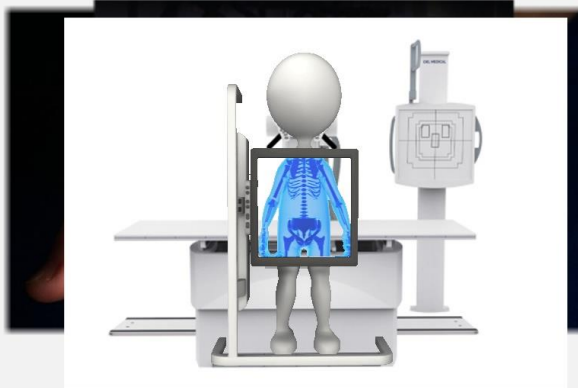
- Radioactive materials are any material that contains unstable atoms that emit radiation.
- Radioactive material may exist in any physical form including a solid, liquid, or gas.
- When radioactive material is transferred or spread to surfaces or the atmosphere it is known as radioactive contamination.
- A simplified definition of radioactive contamination is radioactive material in an unwanted location.

Narration: Radioactive materials are any material that contains unstable atoms that emit radiation. Radioactive material may exist in any physical form including as a solid, liquid, or gas. When radioactive material is transferred or easily spread to surfaces or the atmosphere it is known as radioactive contamination. A simplified definition of radioactive contamination is radioactive material in an unwanted location.

1.9 Radiation Sources

Radiation Sources

Radiation can be emitted from other sources other than radioactive materials. X-ray machines for example have certain physical processes that may cause the production of ionizing radiation. The operation of accelerators like the one found at TA-53 can also cause the production of ionizing radiation and material.



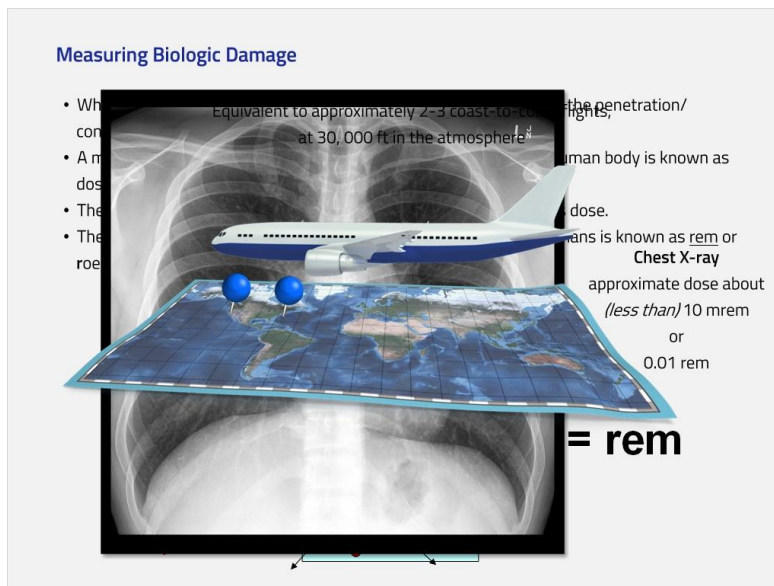
Narration:

Radiation may be emitted from other sources other than radioactive materials. X-ray machines for example have certain physical processes that may cause the production of ionizing radiation. The operation of accelerators like the one found at TA-53 can also cause the production of ionizing radiation and material.

When individuals are exposed to radiation, the radioactive energy is deposited in the body. This does not make the individual radioactive or cause them to become contaminated.

Let's say you took your smart phone's flashlight to your hand. Your hand would absorb the light, and there may be some heating on bodily tissue; however, your hand doesn't become a light source or emit light due to absorption.

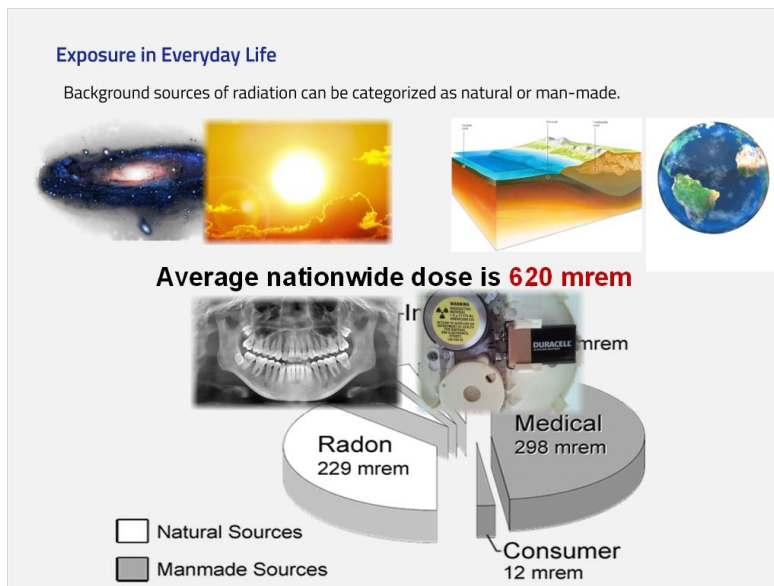
1.10 Measuring Biologic Damage



Narration: When your body absorbs radiation, your tissue may be damaged by the penetration and conversion of the radioactive energy. A method for monitoring and measuring radiation damage to the human body, and to ensure it's kept to a minimum, is known as dosimetry. The amount of radioactive energy absorbed in the body is known as dose. The special unit for measuring radiation in humans is known as rem or roentgen equivalent to man. The rem is a unit for equating radiation absorption with biological damage.

Since the REM is a large unit of measurement, radiation exposure is recorded in thousands of a rem or millirem. For instance, let's say you go to the doctor to receive a chest x-ray the approximate dose would be about (less than) 10 mrem or 0.01 rem. The same amount would be equivalent to approx. 2-3 coast-to-coast flights, at 30,000 ft in the atmosphere, from elevated cosmic radiation levels in the upper atmosphere. In the next lesson, we will discuss natural and man-made sources of radiation.

1.11 Exposure in everyday life



Narration: Humans are always exposed to radiation from background sources; however, most are not exposed as a consequence of their occupation. Background sources of radiation can be categorized as natural or man-made.

Exposure to natural background cosmic radiation comes from the sun and outer space. Natural terrestrial background radiation comes from the earth's crust from rocks, soils, and radon. Man-made sources of radiation come from medical and dental x-rays, nuclear medicine, and consumer products such as the americium-241 in smoke detectors or thorium found on lantern mantels.

In the United States, your average background radiation dose is 620 mrem per year (Show the composite graphic)

1.12 Acute/Chronic Doses

Acute/Chronic Doses

Some work at LANL involves radiation exposure to workers above normal background radiation that we are all exposed to.

Acute dose

- Radiation dose received in a short period of time
- Typically a relatively large amount of radiation



Chronic dose

- Radiation dose received over a long period of time
- Typically a relatively low level of radiation
(0.62 rem x 75 years) = 47 rem



Narration: Some work at LANL involves radiation exposure to workers above the normal background radiation that we are all exposed to.

Large doses received in short periods of time otherwise known as acute doses can cause a range of serious injuries and/or death. We also know that large doses of radiation may cause increase in some forms of cancer. Large doses are not received as a result of occupational exposure here at LANL. Stringent dose limits prevent measurable increases in radiological effects from chronic doses, or small doses received over a long period of time.

The risks associated with occupational radiation doses are considered acceptable in comparison with other occupational risks.

1.13 Somatic vs. Heritable Effects

Somatic vs. Heritable Effects


The effects of radiation damage may appear in exposed individuals or may be passed onto their children

Somatic effect
- occurs in the individual exposed to the radiation
"What is exposure going to do to ME?"

Heritable effect
- is passed on to the offspring of the individual exposed to radiation
"If I get exposed to radiation, will I pass on a birth defect to MY CHILDREN?"

The risks factors of exposure to radiation depend on:

- The radiation type (alphas, betas, gammas)
- The total dose received
- The period of time over which the dose has been received
- The part of the body that received the dose



Narration:

The effects of radiation damage may appear in exposed individuals or may be passed on to their children.

Effects that present directly in exposed individuals are known as **somatic effects**. When the effects indirectly present in the children of the exposed person, these are called **heritable effects**.

No heritable effects in children of exposed persons have been observed in populations that have been clearly linked to chronic, low-level exposure.

The risks factors of exposure to radiation depend on:

- The radiation type (alphas, betas, gammas)
- The total dose received
- The period of time over which the dose has been received
- The part of the body that received the dose

1.14 Prenatal Risks



Narration: Radiation exposure is extremely detrimental for an embryo or developing fetus because embryonic or fetal cells rapidly divide. High dose radiation exposure can result in miscarriage, low birth weight, mental retardation, birth defects, and increased risk of developing cancer and other diseases.

Because the effects of low doses radiation exposure are not precisely known it is wise to avoid any unnecessary radiation exposure during pregnancy.

If you are pregnant, and have the potential for exposure to radiation in the workplace, you're encouraged to notify your supervisor and/or Occupational Medicine (OM) in writing.

The Reproductive Health Assistance Program or RHAP will evaluate your work situation to determine if your job tasks must be modified to minimize exposure and will provide the option for temporary job reassignment.

You are protected from discrimination by Title VII of the Civil Rights Act of 1964 while on reassignment to which occupational radiation exposure is unlikely.

1.15 Occupational and Health Risk Exposure Comparisons

Occupational and Health Risk Exposure Comparisons

- The average radiation dose received from occupational exposure by DOE employees and site workers is 63 mrem per year.
- Health risks can be evaluated by comparing the average days of life lost from various occupations. These health risks of occupational radiation exposure are very low when compared with other occupations.
- The following chart compares the average number of days of life loss in occupations with continuous radiation exposure at 100 mrem per year.

Average Occupational Radiation Dose *	
Occupation	mrem per year
DOE employees and site workers (radiological work activities)	63
Electrician	227
Medical personnel (Patient diagnosis/treatment)	70
Nuclear power plant workers (radiological work activities)	300
Radiation worker with a dose of 100 mrem/year	10
Airline flight crew members (cosmic radiation)	400-600

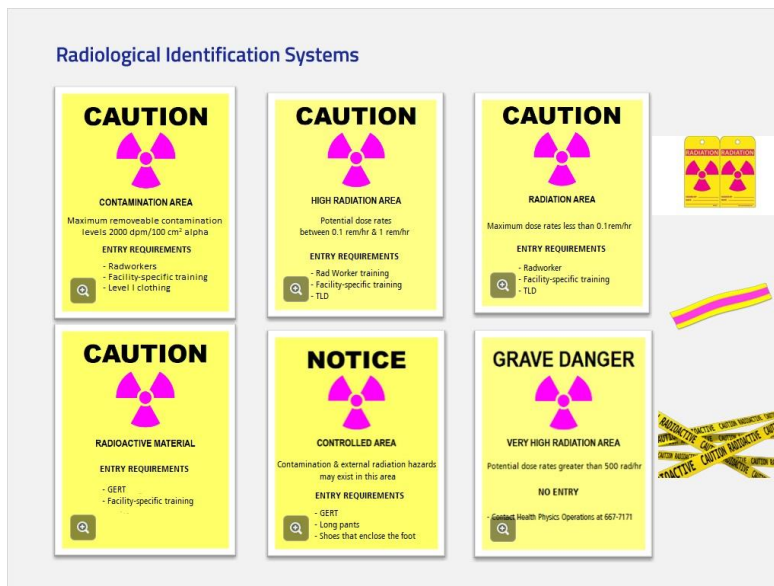
*In addition to background radiation doses; reported in DOE-HDBK-1131-2007.

Narration: The average radiation dose received from occupational exposure by DOE employees and site workers is 63 mrem per year. The following chart compares this amount with the average radiation doses received by workers in other occupations

Health risks can be evaluated by comparing the average days of life lost from various occupations. The health risks of occupational radiation exposure are very low when compared with other occupations.

The following chart compares the average number of days of life loss in occupations with continuous radiation exposure at 100 mrem per year.

1.16 Radiological Identification Systems



Narration: LANL uses various radiological identification systems and controls to protect workers from exposure to radiation.

All areas, materials, and machines that are controlled for radiological purposes are identified by posted signs, tags, or labels, combined with physical barriers where appropriate.

The universal symbol for radiation otherwise known as the (trefoil), has distinguishing color combinations of black or magenta on a yellow background that helps to make radiological hazards easy to recognize.

Radiological workers may not place, modify, relocate, or remove any radiological posting throughout the lab. Only Radiological Control Technicians and authorized Health Physics staff may perform those activities. If postings are incorrect or missing, contact the RCT and do not enter the area until the issue is resolved.

1.17 Recognizing radiological hazards

Recognizing Radiological Hazards

Areas or materials that are controlled for radiological purposes are identified by one or more of the following indicators:

1. Yellow or magenta and black signs bearing the trefoil with appropriate radiological control information, posted at areas where radiological hazards exist
2. Black or magenta on yellow tags and labels bearing the trefoil that identify specific radiological hazards within an area controlled for radiological purposes
3. Yellow and magenta ropes, tapes, chains, or other barriers that define the boundaries of posted areas
4. Yellow plastic wrapping or labeled containers bearing the trefoil that package radioactive materials



Narration: Areas or materials that are controlled for radiological purposes are identified by one or more of the following indicators:

1. Yellow or magenta and black signs bearing the trefoil with appropriate radiological control information, posted at areas where radiological hazards exist
2. Black or magenta on yellow tags and labels bearing the trefoil that identify specific radiological hazards within an area controlled for radiological purposes
3. Yellow and magenta ropes, tapes, chains, or other barriers that define the boundaries of posted areas
4. Yellow plastic wrapping or labeled containers bearing the trefoil that package radioactive materials

Established by DOE 10 CFR 835, areas controlled for radiological purposes are based on the potential for external radiation exposure and/or the potential for contamination. At LANL, signs for these areas have a black or magenta trefoil with black lettering on a yellow background. Specific signs for each area alert workers to the type and/or level of radiation present.

1.18 Designated Rad Area Types

Designated Rad Area Types

There are several designated work areas you should be familiar with as a LANL employee.

1. **Controlled Areas for legacy contamination:** is an area that has relatively low radiological risk, controlled access, and is surrounded by radiological buffer or radiological areas
2. **Radiological Buffer Areas:** is an area that has a relatively higher radiological risk, controlled access, and are considered boundary areas around radiological areas that contain greater hazards
3. **Radiological areas** contain identified radiological hazards; these areas include Radiation, Contamination, and Airborne Radioactivity Areas



Narration: There are several designated work areas you should be familiar with as a LANL employee.

1. Controlled Areas for legacy contamination is an area that has relatively low radiological risk, controlled access, and is surrounded by radiological buffer or radiological areas
2. Radiological Buffer Areas is an area that has a relatively higher radiological risk, controlled access, and are considered boundary areas around radiological areas that contain greater hazards
3. Radiological areas contain identified radiological hazards; these areas include Radiation, Contamination, and Airborne Radioactivity Areas


Some radiological areas are controlled for legacy contamination. In these areas, no accessible contamination is known to exist, but contamination may be present in programmatic systems, under paint, or in other inaccessible areas within the facility or area.

When complete historical knowledge is in question or when radionuclides are known to be present, employees should obtain approval from Radiation Protection Operations before working on or breaching facility systems, surfaces, or programmatic equipment. Contact the area RCT prior to removal of items or equipment from areas controlled for legacy contamination.

To help you identify radiological postings you will see while working here at LANL, here are some examples

1.19 Training Requirements for Entering Designated Areas

Training Requirements for Entering Designated Areas



- Specific training is required to enter *(without a qualified escort)* designated areas controlled for radiological purposes.
- DOE divides the workforce into “general employee” and “radiological worker” categories.
- The following table lists the type of training required for unescorted entry into specific areas.

This level of training ...	allows unescorted entry into a ...
General Employee Radiological Training	Controlled Area
	RMA
Radiological Worker I/II Training	Controlled Area
	Radiological Buffer Area
	Radiation Area
	Contamination Area
	Airborne Radioactivity Area

Narration:

Specific training is required to enter (without a qualified escort) designated areas controlled for radiological purposes. DOE divides the workforce into “general employee” and “radiological worker” categories. The following table lists the type of training required for unescorted entry into specific areas.

Additional entry requirements may exist for access to areas controlled for radiological purposes. Additional facility-specific training may be required at individual facilities throughout the Laboratory.

1.20 ALARA Program

ALARA Program

- The DOE regulates that LANL maintain doses As Low As Reasonably Achievable (ALARA) as a major part of its radiation protection program (10 CFR 835.101(c))
- Personnel must be aware of and understand the radiological hazards around them
- Keep doses ALARA by following the principles of Time, Distance, & Shielding



Minimize
Time



Use Appropriate
Shielding

Narration: Los Alamos National Lab is expected to keep occupational dose from radiation and radioactive material as low as reasonably achievable through the performance of all site activities. Exposures that result in dose to personnel must be justified based on the work that is being performed. Employees are expected to keep their dose reasonably low by understanding where radiological hazards exist and by following a few basic principles while working around radiation and radioactive material.

1.21 Justification

Justification

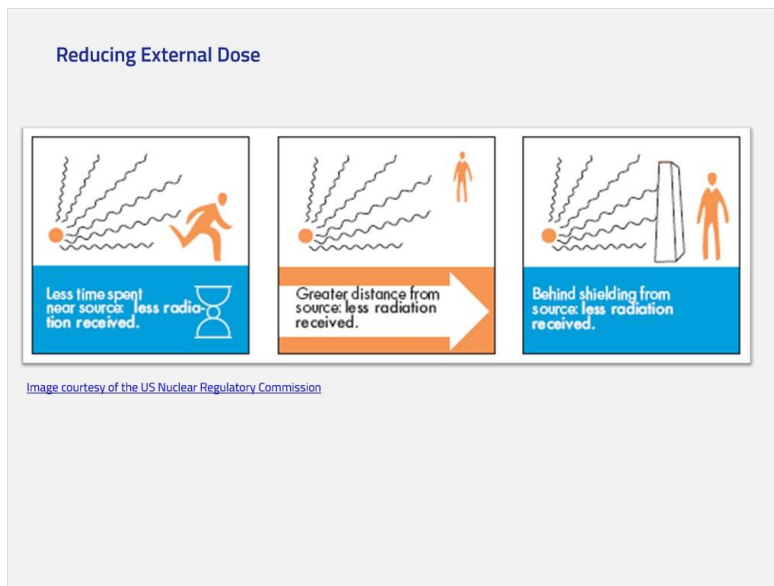
- Any decision that alters the radiation exposure situation should do more good than harm
- Los Alamos' mission is to solve national security challenges through scientific excellence.
- **Mission:**
 - Deterrence and Stockpile Stewardship
 - Protecting Against Nuclear Threats
 - Emerging Threats and Opportunities
 - Energy Security Solutions



Narration: Our laboratory allows for reasonable occupational exposure to radiation and radiological material based on our mission and the work we perform. The mission of the laboratory is to solve national security challenges through scientific excellence. The listed benefits must justify our actions to allow us to take on dose.

We are able to justify our work with radiation and radiological material in two ways. First, we consider planned activities and their impact on occupational and public exposures. Second, we consider routine and emergency exposure situations where pathways of exposure would impact the dose received by occupational workers and the public.

1.22 Reducing External Dose



Narration: Although there is justification for occupational exposure, we can still do more to ensure that individuals doses received are As Low As Reasonably Achievable (or ALARA); meaning well below the limitation that is set by the DOE.

To protect ourselves from and during exposure situations, employees should be aware of their surroundings and the radiological hazards that could be present around them. By minimizing the time, maximizing the distance, and using existing or temporary shielding around sources of radiation that are external exposure hazards, personnel will keep their doses low.

1.23 ALARA Principle #1: Time

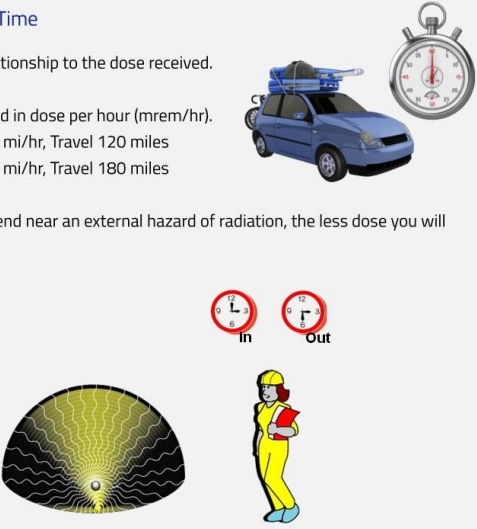
ALARA Principle #1: Time

Time has a linear relationship to the dose received.

Dose rate is measured in dose per hour (mrem/hr).

- 2 hours at 60 mi/hr, Travel 120 miles
- 3 hours at 60 mi/hr, Travel 180 miles

The less time you spend near an external hazard of radiation, the less dose you will receive.



The illustration includes a blue car with a radiation source on its roof, a stopwatch, and a person in a yellow protective suit standing near a radiation source. Above the person are two circular clocks labeled 'In' and 'Out'.

Narration: To begin our discussion on ALARA or As Low As Reasonable Achievable, let's explore how time would affect the amount of dose that an individual would receive. When considering external exposure hazards, we measure the dose rate that a radiation source emits while standing in a specific location.

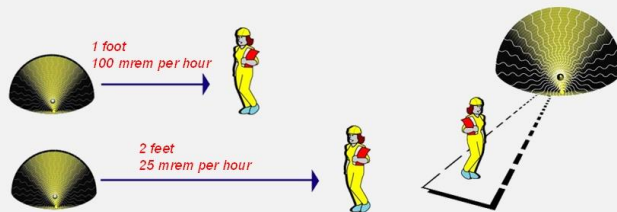
For instance, let's say you were to stand in place for an hour where there is a dose rate of 10 mrem/hr, in turn you would receive 10 mrem of dose. Now, let's say you were to stick around for two hours, your dose would double to 20 mrem because you were standing in the same location for twice the duration. Time has a linear effect on the dose that you receive. Another way to think about the time vs dose concept, is if you go on a road trip. Your speed is like the dose rate you receive. If you travel at 60 mi/hr for two hours, you will have gone 120 miles. Add another hour on the road, and you will have gone another 60 miles, or 180 miles.

Consider that the less time that you spend around an external hazard of radiation, the less dose you will receive.

1.24 ALARA Principle #1: Distance

ALARA Principle #2: Distance

- Distance has an exponential relationship to the dose received based on the inverse square law.
- Inverse Square Law: $1/4$ distance squared
 - External exposure radiation hazard that has a dose rate of 100 mrem/hr at 1 foot
 - At 2 feet away from the source, you receive 25 mrem/hr or $1/4$ of the dose rate
- The greater your distance from an external hazard of radiation, the less dose you will receive.



Narration: There is an exponential relationship with distance from a radiation source, and the dose rate you would be exposed to. This means that there is an even greater effect on the dose that you would receive by increasing your distance from a source of radiation than by spending less time around that source of radiation.

Inverse Square Law: $1/4$ distance squared

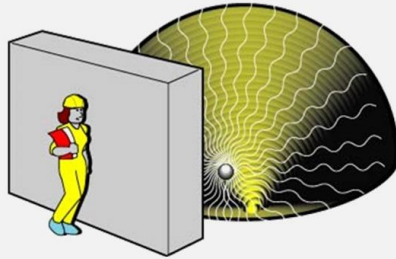
- For an external exposure radiation hazard that has a dose rate of 100 mrem/hr at 1 foot.
- At 2 feet away from the source, you receive 25 mrem/hr or $1/4$ of the dose rate

The greater your distance from an external hazard of radiation, the less dose you will receive.

1.25 ALARA Principle #3: Shielding

ALARA Principle #3: Shielding

- Shielding is an engineered control designed to reduce the dose rate of a radiation source to acceptable levels.
- Shielding is developed when a space is designated to become a radiological area. Considerations are made for the type of hazard present and who occupies space around the radiological areas.
- Under normal operating conditions, shielding will maintain dose rates below limits based on the population it is designed to protect.



Narration:

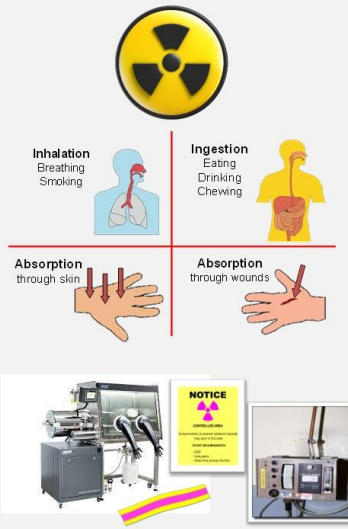
The final ALARA principle we will discuss in this course is shielding. Shielding is an engineered solution for reducing the exposure rate of sources. Shielding can be designed to be installed around high-exposure sources (either permanently or temporarily), or it can be incorporated in room walls that sources are housed in.

Shielding can be designed to reduce the dose rate to acceptable levels within or outside of radiological areas based on occupancy limits.

1.26 Reducing Internal Dose

Reducing Internal Dose

- Radioactive contamination can contribute to the internal dose that a person receives through inhalation, ingestion, and absorption or injection through skin.
- To reduce internal dose where contamination exists, engineered and procedural solutions are also present to reduce exposure.
- For example:
 - contamination is contained within equipment such as gloveboxes
 - material or equipment is segregated from areas of traffic using barriers and signage
 - areas and equipment that have been contaminated are thoroughly decontaminated
 - airborne contamination is controlled using filtered ventilation systems



Narration: Radioactive contamination can contribute to the internal dose that a person receives through inhalation, ingestion, and absorption or injection through skin. In order to reduce the int

ernal dose one receives, there are a number of controls in place and that may be employed by personnel. In areas where contamination exists, engineered and procedural solutions are also present to reduce exposure. For example,

- contamination is contained within equipment such as glove boxes,
- it is segregated from areas of traffic using barriers and signage,
- areas and equipment that have been contaminated are thoroughly decontaminated
- airborne contamination is controlled using filtered ventilation systems.

As you recall, please refer to the radiological identification systems in the previous lesson for examples postings, signs, and labels

1.27 Reducing Internal Dose cont.

Reducing Internal Dose

- To reduce internal contamination, use personnel protective equipment or PPE.
- Anti-C clothing keeps material away from our skin and respirators are used with airborne hazards to keep higher concentrations of airborne material from being inhaled.
- We use of personnel contamination monitors to check for contamination on ourselves after leaving contamination areas.
- We Do Not allow any eating, drinking, smoking, chewing, or applying of cosmetics in contamination areas.



Narration: Another way to significantly reduce internal contamination is through the proper use of personnel protective equipment or PPE. When used properly, we are able to control the interaction that loose radioactive material has with our bodies. Anti-C clothing keeps material away from our skin and respirators are used with airborne hazards to keep higher concentrations of airborne material from being inhaled. Further, we use personnel contamination monitors to check for contamination on ourselves after leaving contamination areas.

Policy states that we do not allow any eating, drinking, smoking, chewing, or applying of cosmetics in contamination areas. Following these policies helps us protect you from ingesting material as it comes into contact with our mouths.

1.28 Source Reduction

Source Reduction

- Source reduction or elimination is the practice of removing unnecessary sources of radiation or radioactive contamination from an area in order to reduce dose to personnel.
- If sources of radiation may be replaced by a non-radioactive substitute, there will be consideration to evaluate the appropriateness of the substitution, and these sources may be replaced.
- Examples of source reduction or elimination include:
 - Replacing high-activity radioactive material with radiation-generating equipment
 - Removal of radioactive waste from work areas on a regular basis
 - Storing radioactive material in proper designated locations
 - Bag-out of glovebox materials to reduce the amount of activity in the box



Narration:

Source reduction or elimination is the practice of removing unnecessary radiation or radioactive contamination from an area in order to reduce dose to personnel.

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Some examples of source reduction or elimination include:

- Replacing high-activity radioactive material with radiation-generating equipment
- Removal of radioactive waste from work areas on a regular basis
- Storing radioactive material in proper designated locations
- Bag-out of glovebox materials to reduce the amount of activity in the box

1.29 Employee Responsibilities

Employee Responsibilities

You are a key component in keeping radiation doses ALARA.

You act responsibly when you:

- Obey all signs and postings
- Comply with all radiological and safety rules
- Do not enter any radiological areas without proper training unless escorted by a qualified Rad Worker
- **If escorted, you must:**
 - Obey the instructions of your escort
 - Obtain and wear dosimeters as instructed by your escort, Radiological Control personnel, or procedure
 - Utilize ALARA techniques to control your exposure
- **Maintain awareness and report any unusual radiological situations**
- Maintain contact with Radiological Control personnel
- **Comply with emergency procedures for your work area**
- Keep your doses ALARA and know what your administrative control levels and dose limits are
- Know your cumulative and annual dose



Narration: Each and every employee has the potential to impact the ALARA program at Los Alamos National Lab. Remember that you are responsible for your dose and the impact you have on the dose of others. Awareness of your situation is important for your understanding of what is going on around you. Make sure that you comply with all signs, postings, and rules related to the areas you visit.

Do not enter areas that you are not permitted to go, and know what those areas are. If you are not permitted unescorted access to an area, understand that you must be escorted through these areas by a knowledgeable escort, and that you are required to obey and follow the instructions of your escort. Always keep the principles of ALARA in mind and know your dose limits.

1.30 Dealing with Emergencies

Emergencies

- Be prepared for emergencies by knowing how to respond to them ahead of time
- Emergency procedures and alarms vary depending on the facility and work area you are in. You should know:
 - The emergency procedures specific to your work area
 - The alarms specific to your work area that warn of different hazards
 - How to contact emergency personnel and the RCT assigned to the work area
 - The location of emergency contact lists for your work area
- Dial 911: For emergencies requiring police, fire, or emergency medical support.
- Call the Emergency Operations Support Center (EOSC) for any other emergencies, or after calling 911. (505) 667-2400



Narration: The best time to know how to deal with emergencies is before one occurs, so it is important to take preventive measures by familiarizing yourself with emergency procedures, alarms, and contact information ahead of time.

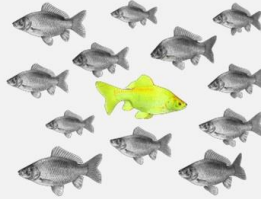
You are responsible for your understanding of how to properly deal with emergency situations. During emergencies, the environment can be confusing and chaotic. If you are well informed of how to respond, you will be confident in your actions and will facilitate smooth emergency response.

1.31 Abnormal Conditions

Abnormal Conditions

You notice that radioactive material is not where it belongs, you need to take the following steps:

1. Do not touch or handle the material
2. Warn other personnel not to approach the area
3. Guard the area to prevent personnel from entering after moving a safe distance away from it.
4. Have someone notify Radiological Control personnel
5. Await Radiological Control personnel and follow their instructions



Narration: Here's an important question. What would you do if you notice that there is radioactive material missing or out of place? The answer is, you could be in the middle of a hazardous situation, so immediate action is important.

First, make sure that you do not try to touch or handle the material on your own.

Second, make sure that other people are aware of the situation and that you all get a safe distance away from the material. While guarding the area, send someone to contact Radiological Control Technician so that they may respond to the situation. Comply with all instructions that are given by the Radiological Control personnel.

1.32 Facility Alarms

Facility Alarms

- Emergent situations can be confusing and chaotic
- Know how to respond to specific emergencies before they occur
- Be confident in your response and support others as you respond
- Know facility-specific alarms and evacuation points



Narration: During an emergency situation, you must be confident to act appropriately. When an alarm sounds, there may be confusion from others around you, so being aware of the different types of radiological alarms and how you should respond to them ahead of time will be vital for your response as well as the support of others.

There are two radiological alarms that we will discuss: the Area Radiation Monitor (ARM alarm) and the Continuous Air Monitor (CAM alarm). Be aware that these alarms may sound different between LANL facilities, so you will want to work with the RCT assigned to specific facilities to understand what each alarm sounds like. Radiological Control personnel will also inform you as to where you should evacuate to for each alarm.

1.33 Area Radiation Monitor

Area Radiation Monitor

- Area Radiation Monitors monitor for far-traveling radiations
- Shielding within and around radiological areas is designed for normal operation
- When an ARM alarms, exposure rates are higher, so you must respond
 - Stop work safely and leave the area immediately
 - Report to the identified safe area
 - Contact Radiological Control personnel



Narration:

The Area Radiation Monitor or ARM alarm is used to measure far-traveling radiations, such as gamma, x-ray, and neutron radiation. These monitors measure the exposure rates at their locations, and will sound an alarm once the exposure rate reaches past suspensions levels. Shielding protecting areas outside of and within radiological areas are designed to keep doses well below laboratory limits. So if you hear an ARM alarm, evacuate immediately to a controlled area or anti-c assembly area.

1.34 Continuous Air Monitor

Continuous Air Monitor

- Continuous Air Monitors monitor for airborne radioactivity
- When spills occur or containment is breached, concentrations of airborne activity may increase
- When a CAM alarms, concentrations of airborne radioactivity are higher, so you must respond
 - Stop work safely and leave the area immediately
 - Report to the identified safe area
 - Contact Radiological Control personnel



Narration: The Continuous Air Monitor or CAM alarm is used to measure the internal hazard of airborne radioactivity present in a volume of air. Airborne radioactivity emits radiation. These monitors measure the airborne concentrations at their locations, and will sound an alarm once concentrations reach suspension levels that suggest the situation has changed. If you hear a CAM alarm, it means that radiation may have become aerosolized. You must evacuate immediately to a controlled or anti-c assembly area if you hear this alarm sounding.

1.35 Dose Monitoring

Dose Monitoring

- The dose monitoring program demonstrates to the DOE that we understand, and appropriately respond to, radiological conditions around the laboratory
- Personnel dose is monitored through external dosimetry and internal bioassay
- Not all personnel are monitored through the dosimetry program
- You may request monitoring from Dosimetry Services even if you are not expected to receive doses that require monitoring
 - Dosimetry Services will consider the request and ultimately determine if personnel who are not required to be monitored shall be monitored



Narration: Dose monitoring is a required as part of LANL's radiation protection program. We are able to demonstrate to the DOE that LANL understands the radiological conditions in its controlled areas and has employed effective engineered and administrative controls to keep doses to personnel well below limits. Dose monitoring also enables the detection as radiological conditions changes as they arise.

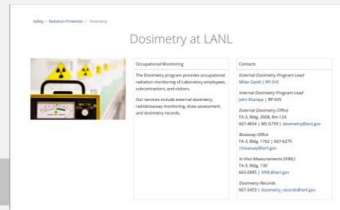
For personnel, there are two ways that we conduct dose monitoring: 1.) through external dosimetry and the second is through internal bioassay. We will discuss each method in the next few scenes.

Not all personnel are monitored for dose. If you are not expected to receive more than a certain minimum dose based on your work situation and job tasks, you will not be enrolled in the dosimetry program. Dosimetry Services and your responsible line manager will determine whether or not to enroll you in the program.

1.36 Dose Monitoring cont.

Dose Monitoring cont.

- Use the Health Physics Checklist on LANL's Dosimetry website to evaluate if and what program the employee will be registered for.
- Supervisors will make requests for the assignment of dosimetry services for required individuals
- Any time there is a duty change which may affect monitoring requirements, the Health Physics Checklist must be filled out again



Narration: In order to determine if you need to be enrolled in LANL’s dosimetry program, you will need to fill out the Health Physics checklist found on the Dosimetry website. This checklist will determine what monitoring programs you need to be enrolled in, if any. Your supervisor will make a request for permanent dosimetry if they expect that you will be performing tasks which require dosimetry or bioassay. If you change job roles or duties that may affect monitoring requirements, you must fill out the Health Physics checklist again to determine appropriate monitoring programs for your situation.

1.37 External Dose Monitoring

External Dose Monitoring

- External dosimetry is assigned to record dose to an individual from external sources
- External monitoring is only required for personnel who:
 - are likely to receive an effective dose of at least 100 mrem/yr
 - declared pregnant workers who are likely to receive at least 50 mrem from external sources during their pregnancy
 - Minors likely to receive at least 50 mrem in a year from external sources
 - Members of the public entering a controlled area likely to receive 50 mrem in a year from external sources
 - Individuals entering a high or very high radiation area



Narration: If you are likely to receive an effective dose of at least 100 mrem/yr, or you are a declared pregnant worker (*refer back to the RHAP program in lesson 2*) likely to receive 50 mrem per month throughout a term of pregnancy, a minor or a member of the public who will likely at least 100 mrem in a year, or any individual who enters a high or very high radiation area, you will be assigned external dosimetry.

1.38 External Dose Monitoring cont.

External Dose Monitoring cont.

- The TLD is used to monitor personnel for external exposure to radiation
- The TLD must be worn in accordance with Dosimetry Services instructions
- Do not leave TLD in a hot location, such as the dash of a car, as this will affect recorded dose
- Do not travel with TLD. It is to only be used onsite at LANL
- Immediately report a lost TLD
- Report any incidence of exposure to TLD outside of LANL to Dosimetry Services
- Inform Dosimetry Services of medical procedures or diagnostics that utilize radiopharmaceuticals prior to your procedure



Narration: The thermo-luminescent dosimeter (TLD) is a dosimetry device assigned to personnel who are being monitored for external dose. It is important that the TLD be worn whenever an assigned individual enters a radiological area. The TLD must be worn as indicated by Dosimetry Services, typically on the center of the body between the neck and the waist.

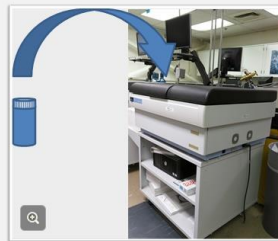
- Do not leave the TLD in a hot location, such as the car dashboard. The heat will interfere with the TLD readout of its collected dose.
- Do not travel with the TLD. The TLD is expressly used at LANL for occupational dose received at this location. Report any incidents of exposure to the TLD outside of LANL to Dosimetry Services.
- If the TLD is lost, you must immediately report to Dosimetry Services so they may assign you a new dosimeter and interview you to estimate prior dose received.

If you are to receive a medical procedure or diagnostics involving radiopharmaceuticals, report to Dosimetry Services ahead of time so they can provide guidance regarding use of your TLD.

1.39 Internal Dose Monitoring

Internal Dose Monitoring

- Internal dose is monitored through bioassay. Bioassay may be completed through two types of monitoring:
 - *In Vivo Monitoring*: Measurement of internalized radioactivity through readings taken from outside of the body
 - *In Vitro Monitoring*: Measurement of internalized radioactivity by analysis of material found in bodily fluids and excretions
- Internal dose is extrapolated from the information found through bioassay while considering where it will concentrate in the body and how long it will remain there.
- A committed effective dose is assigned to the person. 50 years of dose from the internalized radioactivity is assigned all at once.



Narration: Internal dose is measured and applied differently than external dose. A bioassay is performed to assess radiation being emitted from within the body. Bioassays can be conducted on the entire-body, on the chest, thyroid, or wound counters in a process called in vivo monitoring. Samples of bodily fluids and excretions can be analyzed through a process called invitro monitoring. A committed effective dose based on what is found in the body will be assigned to the individual's dose of record. This takes into account the dose that will be received over the next 50 years from the radioactivity present in the system.

1.40 Exposure Reports

Exposure Reports

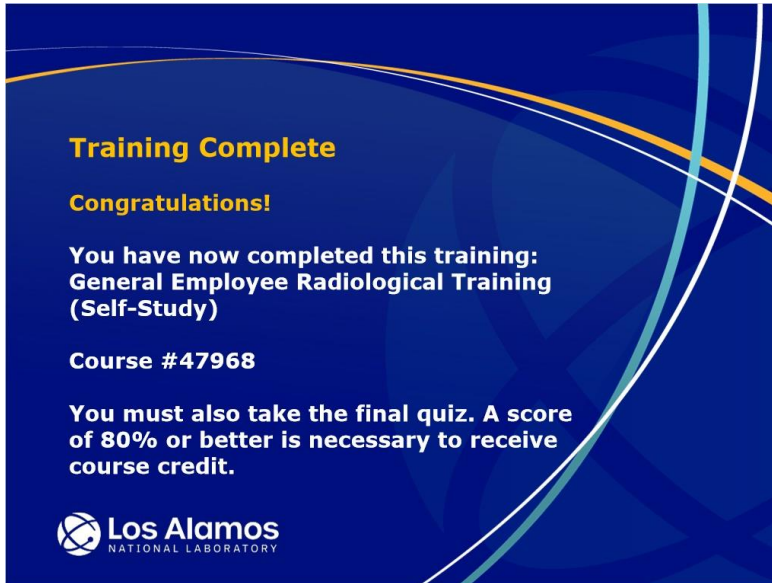
- Radiation exposure dose records will be maintained for any employee who has been assigned dosimetry or to the bioassay program
- Individuals who have been monitored for exposure have the right to request reports of exposure. Information regarding radiation exposure dose shall be provided:
 - *Upon Termination:* Records of exposure dose shall be provided within 90 days. If requested, a written estimate of radiation exposure will be provided at the time of termination.
 - *On an Annual Basis:* Each individual who is required to be monitored for radiation exposure
- If an individual is not required to be monitored, the annual report is not required to be sent on an annual basis. However, it may still be requested.
- To obtain dose records, follow the "Request my dose history" or "Review my dosimetry results" links on the Dosimetry website, or email dosimetry_records@lanl.gov



Narration: In the event that you are ever assigned dosimetry or to the bioassay program, your radiation doses will be recorded, and the records of your received doses will be maintained. Dose reports are provided to dosimetryenrolled

employees on an annual basis, and an entire dose history report is sent to personnel within 90-days of termination. Dosimetry results can be accessed anytime by following the "Request my dose history" or "Review my dosimetry results" links found on the LANL Dosimetry webpage. You may also request your dose records by sending an email to the dosimetry team at dosimetry_records@lanl.gov.

1.42 End of Course

A blue screen with white and yellow text. It features a stylized graphic of a globe with latitude and longitude lines in the background. The text is centered and reads: "Training Complete", "Congratulations!", "You have now completed this training: General Employee Radiological Training (Self-Study)", "Course #47968", and "You must also take the final quiz. A score of 80% or better is necessary to receive course credit." At the bottom left is the Los Alamos National Laboratory logo.


Training Complete

Congratulations!

You have now completed this training:
General Employee Radiological Training
(Self-Study)

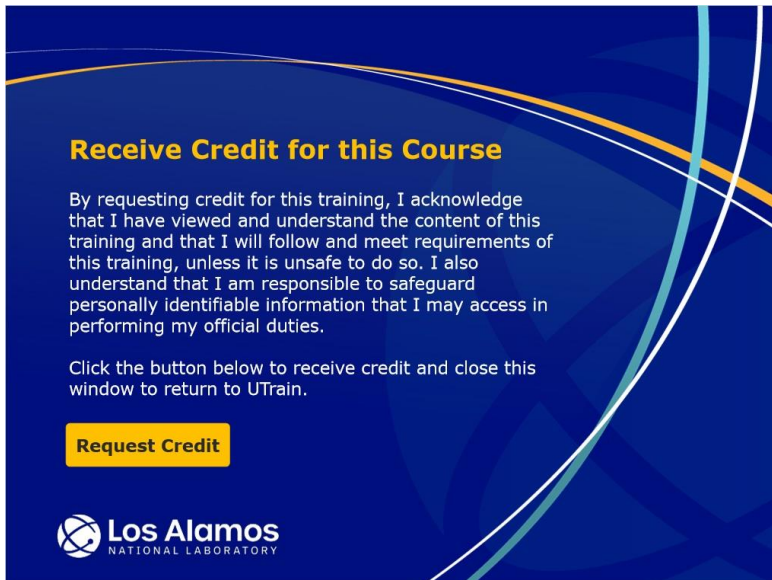
Course #47968

You must also take the final quiz. A score of 80% or better is necessary to receive course credit.

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Notes:

1.43 Exit


A blue screen with white and yellow text. It features a stylized graphic of a globe with latitude and longitude lines in the background. The text is centered and reads: "Receive Credit for this Course", "By requesting credit for this training, I acknowledge that I have viewed and understand the content of this training and that I will follow and meet requirements of this training, unless it is unsafe to do so. I also understand that I am responsible to safeguard personally identifiable information that I may access in performing my official duties.", "Click the button below to receive credit and close this window to return to UTrain.", and a yellow button labeled "Request Credit". At the bottom left is the Los Alamos National Laboratory logo.

Receive Credit for this Course

By requesting credit for this training, I acknowledge that I have viewed and understand the content of this training and that I will follow and meet requirements of this training, unless it is unsafe to do so. I also understand that I am responsible to safeguard personally identifiable information that I may access in performing my official duties.

Click the button below to receive credit and close this window to return to UTrain.

Request Credit

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Notes:

2. Lightboxes

2.1 Objectives

GENERAL EMPLOYEE RADIOLOGICAL TRAINING
OBJECTIVES

01 OBJECTIVE 01 Identify basic radiological fundamentals and radiation protection concepts.	04 OBJECTIVE 04 Identify individual rights and responsibilities as related to implementation of the radiation protection program (including the ALARA Program).
02 OBJECTIVE 02 Identify the relative risks of exposure to radiation and radioactive materials, including prenatal radiation exposure.	05 OBJECTIVE 05 Identify actions implemented to control doses under emergency conditions.
03 OBJECTIVE 03 Identify engineered and administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to control doses.	06 OBJECTIVE 06 Identify exposure reports or other exposure data which may be provided and how to request these reports.

Notes:

Take a moment to review the secondary objectives for this course. We focus on understanding the different roles and responsibilities within IWM, and how these responsibilities relate to the Safe Conduct of Research, or SCoR principles. We also want to make sure that you know the purpose of the Integrated Work Document (or Work Control Document) that is used throughout the work activity. You must use these documents to perform work in a safe, secure, and environmentally responsible manner.

2.2 Radiological Identification Systems

